PATENT SPECIFICATION (11) 1425910

1425910

(21) Application No. 37368/74 (22) Filed 27 Aug. 1974
(31) Convention Application No. 7312361 (32) Filed 7 Sept. 1973 in
(33) Netherlands (NL)
(44) Complete Specification published 25 Feb. 1976
(51) INT CL² G02C 7/02
(52) Index at acceptance
G2J S6B S6D

(19)



(54) DEVICE FOR VIEWING UNDER WATER

(71) We, N. V. OPTISCHE INDUSTRIE DE OUDE DELFT, van Miereveltlaan 9, Delft, Holland, a Dutch Company, do hereby declare the invention for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a device for viewing under water of the kind comprising two identical optical lens systems, each of the systems as seen from the object side to the image side consisting of a first component with a concave surface on the image side, an air space and a second component in the form of a lens of positive power, the nodal point of the first component on the image side thereof substantially coinciding with the nodal point of the second component on the object side thereof, the total dioptric power of each of the systems being substantially zero under water.

In known devices of this kind, see French Parent Specification No. 1,040,064, the optical axes of the optical lens systems are parallel.

It is an object of such devices to increase the field of view under water and to correct the distortion which is experienced under water. However, it is a drawback of the known devices that the field of view is seriously limited on the one hand by the mounting parts of the optical lens systems and on the other hand by the fact that aberrations increase with increasing angle between the line of view and the optical axes. In a non-complicated system for a diving mask, in which the first component and the second component preferably consist of one single optical element, e.g. made of plastic, said angle has a maximum value of 25°.

Assuming a fixed position for the point of rotation of each eye with respect to the optical axis of the respective optical system, which actually will be the case in a diving mask, in practice the field of view appears to be limited to 40°. A further drawback of known devices results from the fact that the distance between the axes of the two eyes is critical as the point of rotation of each of the eyes has to be positioned preferably on the optical axis of the respective optical system.

It is the object of the invention to provide a device of the kind mentioned which does not have the above-mentioned drawbacks.

According to the invention, there is provided a device for viewing under water of the kind wherein the optical axes of the optical lens systems converge towards the image-side and include an angle between 40° and 60°, and one of the two components of each of the optical lens systems includes an aspherical surface.

As a result of the convergence of the optical axes, the mounting parts of the optical systems are positioned partly outside of the field of view, and the possibility of observations of the right eye to the right and of the left eye to the left can be extended to an angle of 45° with respect of the forward direction and the peripheral observation is increased to an angle of 90° with respect to the forward direction. The aspherical shape of a surface of one of the components of each optical lens system results in vision with very small aberrations in the forward direction and, in the case of stereoscopic vision in the overlapping area of vision of the two eyes. Also, positioning of the eyes with respect to the optical axis of its related optical system can be less critical. The combination of the two measures according to the invention in optical systems for a diving mask results in a diving mask having under water, a field of view of 40° in the horizontal plane in which stereoscopic vision is possible, a "sharp" field of view of about 90° and a peripheral view up to about 180°, for an observer with a distance between the eyes between 60 and 68 mm.

The invention will now be described in more detail, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 shows schematically an embodiment of a device according to the invention in the form of a diving mask;

Fig. 2 shows schematically one of two identical optical lens systems which form part of a device according to the invention;

Fig. 3 shows a cross-section of an embodiment in which one component of the optical lens system is provided with an aspherical surface, and

Fig. 4 shows a cross-section of an embodiment in which the other component of the optical lens system is provided with an aspherical surface.

Referring to Fig. 1, two identical optical lens systems 1 and 2 are shown, both systems forming part of a diving mask 3 attached to the face of an observer, the observer's nose and eyes being shown at 4 and at 5, 6 respectively.

The optical lens systems 1 and 2 each consist of a first component 9 e.g. made of plastics material, with a convex surface 10 on the object side thereof, and a concave surface 11 on the image side thereof, and of a second component 12 in the form of a lens with positive dioptric power.

Optical axes 7 and 8 of the two optical lens systems 1 and 2 respectively converge towards the image side and include an angle of about 50°, that is the optical axis 7, 8 of each system 1 and 2 respectively and the formed direction of each of the eyes 5 and 6 respectively include an angle of about 25°.

The space between the first and the second components 9 and 12 contains dry air.

In Figure 2, one of the optical lens systems 1 and 2 of the diving mask 3 is shown, the first and second components being denoted by I and II respectively.

In Figure 3, there is shown a cross-section of the second component II having an aspherical surface.

A device for viewing under water, incorporating a second component, as shown in Figure 3, is characterized in that the optical axes of the optical lens systems include an angle of 50°, the object-sided surface of the second component of each optical lens system is aspherical, and the dimensions, as shown in Fig. 2 of each of the optical lens systems are determined by the following numerical data, in which the dioptric powers of the refractive surfaces may deviate by ±5% of the total power:—

Comp.	Radii of	Axial thickness or separation in dm	Refractive index
I	$r_1=-0.4519$	$d_1=0.0445$	$n_d=1.4926$
	$r_2=-0.4074$	$l_1=0.4074$	
II	$r_{3axis}=-0.7714$	$d_2=0.0800$	$n_d=1.4926$
	$r_4=\infty$		

The distance X between the actual object-sided surface of the second component II and a spherical surface with radius of curvature r_{3axis} parallel to the optical axis at a height y is determined by the following equation:

$$x=0.0239y^3-1.016y^4+13.50y^5-20.44y^6-663.35y^7+2952.92y^8-2782.51y^9+2325.41y^{10}-16972.43y^{11}.$$

where both x and y are expressed in 10^{-1}M.

A device for viewing under water, incorporating a first component as shown in Figure 4, is characterised in that the optical axes of the optical lens systems include an angle of 50°, the object-sided surface of the first component I is provided with an aspherical rim, which rim starts at an angle γ as measured from the optical axis of 33° 22′ 44″, and the dimensions (as set out in Fig. 2) of each of the optical systems is determined by the following numerical data, in which the dioptric powers of the refractive surfaces may deviate by ±5% of the total power:—

Comp. number	Radii of curvature in mm	Axial thickness or separation in mm	Refractive Index
I	$r_1=-45.19$	$d_1=4.45$	$n_d=1.4926$
	$r_{2axis}=-40.74$	$l_1=40.74$	
II	$r_3=-77.14$	$d_2=8.00$	$n_d=1.4926$
	$r_4=\infty$		

As measured in a system of orthogonal axes, in which the x-axis coincides with the radius of the object-sided surface of the first component at an angle of 33° 22′ 44″, and in which the y-axis passes through the point of intersection of the radius at an angle of 33° 22′ 44″ and the object-sided surface of the first component, the distance x in mm between the aspherical rim and an extension of the spherical surface at a height y in mm is determined by the following equation:

$$x = -0.6503y^3 + 83.4008y^4 - 1858.7277y^5 + 23689.3545y^6 - 174858.9840y^7 + 695773.9980y^8 - 1154008.6900y^9.$$

With the embodiments described above good results are obtained and at an angle of 25° the value of the point-spread function is smaller than 2mrad.

WHAT WE CLAIM IS:—

1. A device for viewing under water comprising two identical optical lens systems, each of the systems as seen from the object side to the image side consisting of a first component with a concave surface on the image side thereof, an air space, and a second component in the form of a lens of positive power, the nodal point of the first component on the image side thereof substantially coinciding with the nodal point of the second component on the object side thereof, the optical axes of the optical lens system converging towards the image side and including an angle of between 40° and 60°, one of the two components of each of the optical lens systems comprising an aspherical surface, and the total dioptric power of each of the systems being substantially zero under water.

2. A device as claimed in Claim 1, wherein the optical axes of the optical lens systems include an angle of 50°, the surface of the second component on the object side thereof is aspherical, and the dimensions of each of the optical lens systems are determined by the following numerical data, in which the dioptric powers of the refractive surfaces may deviate by ±5% of the total power,

Comp. number	Radii of curvature in dm	Axial thickness or separation in dm	Refractive index
	$r_1 = -0.4519$		
I		$d_1 = 0.0445$	$n_d = 1.4926$
	$r_2 = -0.4074$		
		$l_1 = 0.4074$	
	$r_{3axis} = -0.7714$		
II		$d_2 = 0.0800$	$n_d = 1.4926$
	$r_4 = \infty$		

the distance X in 10^{-1}M between the actual object-sided surface of the second component and a spherical surface with radius of curvature r_{3axis} parallel to the optical axis at a height y in 10^{-1}M being determined by the following equation:—

$$x = 0.0239y^3 - 1.016y^4 + 13.50y^5 - 20.44y^6 - 663.35y^7 + 2952.92y^8 - 2782.51y^9 + 2325.41y^{10} - 16972.43y^{11}.$$

3. A device as claimed in Claim 1, wherein the optical axes of the optical lens systems include an angle of 50°, the object-sided surface of the first component having aspherical rim, which rim starts at an angle γ as measured from the optical axis, of 33° 22′ 44″, and the dimensions of each of the optical systems are determined by the following numerical data, in which the dioptric powers of the refractive surfaces may deviate by ±5% of the total power,

Comp. number	Radii of curvature in mm	Axial thickness or separation in mm	Refractive Index
	$r_1 = -45.19$		
I		$d_1 = 4.45$	$n_d = 1.4926$
	$r_{2axis} = -40.74$		
		$l_1 = 40.74$	
	$r_3 = -77.14$		
II		$d_2 = 8.00$	$n_d = 1.4926$
	$r_4 = \infty$		

in which, as measured in a system of orthogonal axes, the x-axis of which orthogonal axes coincides with the radius of the object-sided surface of the first component at an angle of 33° 22′ 44″ and the y-axis of which passes through the point of intersection of the radius at an angle of 33° 22′ 44″ and the object-sided surface of the first com-

As measured in a system of orthogonal axes, in which the x-axis coincides with the radius of the object-sided surface of the first component at an angle of 33° 22′ 44″, and in which the y-axis passes through the point of intersection of the radius at an angle of 33° 22′ 44″ and the object-sided surface of the first component, the distance x in mm between the aspherical rim and an extension of the spherical surface at a height y in mm is determined by the following equation:

$$x = -0.6503y^3 + 83.4008y^4 - 1858.7277y^5 + 23689.3545y^6 - 174858.9840y^7 + 695773.9980y^8 - 1154008.6900y^9.$$

With the embodiments described above good results are obtained and at an angle of 25° the value of the point-spread function is smaller than 2mrad.

WHAT WE CLAIM IS:—

1. A device for viewing under water comprising two identical optical lens systems, each of the systems as seen from the object side to the image side consisting of a first component with a concave surface on the image side thereof, an air space, and a second component in the form of a lens of positive power, the nodal point of the first component on the image side thereof substantially coinciding with the nodal point of the second component on the object side thereof, the optical axes of the optical lens system converging towards the image side and including an angle of between 40° and 60°, one of the two components of each of the optical lens systems comprising an aspherical surface, and the total dioptric power of each of the systems being substantially zero under water.

2. A device as claimed in Claim 1, wherein the optical axes of the optical lens systems include an angle of 50°, the surface of the second component on the object side thereof is aspherical, and the dimensions of each of the optical lens systems are determined by the following numerical data, in which the dioptric powers of the refractive surfaces may deviate by ±5% of the total power,

Comp. number	Radii of curvature in dm	Axial thickness or separation in dm	Refractive index
	$r_1 = -0.4519$		
I		$d_1 = 0.0445$	$n_d = 1.4926$
	$r_2 = -0.4074$		
		$l_1 = 0.4074$	
	$r_{3axis} = -0.7714$		
II		$d_2 = 0.0800$	$n_d = 1.4926$
	$r_4 = \infty$		

the distance X in 10^{-1}M between the actual object-sided surface of the second component and a spherical surface with radius of curvature r_{3axis} parallel to the optical axis at a height y in 10^{-1}M being determined by the following equation:—

$$x = 0.0239y^3 - 1.016y^4 + 13.50y^5 - 20.44y^6 - 663.35y^7 + 2952.92y^8 - 2782.51y^9 + 2325.41y^{10} - 16972.43y^{11}.$$

3. A device as claimed in Claim 1, wherein the optical axes of the optical lens systems include an angle of 50°, the object-sided surface of the first component having aspherical rim, which rim starts at an angle γ as measured from the optical axis, of 33° 22′ 44″, and the dimensions of each of the optical systems are determined by the following numerical data, in which the dioptric powers of the refractive surfaces may deviate by ±5% of the total power,

Comp. number	Radii of curvature in mm	Axial thickness or separation in mm	Refractive Index
	$r_1 = -45.19$		
I		$d_1 = 4.45$	$n_d = 1.4926$
	$r_{2axis} = -40.74$		
		$l_1 = 40.74$	
	$r_3 = -77.14$		
II		$d_2 = 8.00$	$n_d = 1.4926$
	$r_4 = \infty$		

in which, as measured in a system of orthogonal axes, the x-axis of which orthogonal axes coincides with the radius of the object-sided surface of the first component at an angle of 33° 22′ 44″ and the y-axis of which passes through the point of intersection of the radius at an angle of 33° 22′ 44″ and the object-sided surface of the first com-

* C L M S *

ponent, the distance x in mm between the aspherical rim and an extension of the spherical surface at a hight y in mm is determined by the following equation:

$$x = -0.6503y^3 + 83.4008y^4 - 1858.7277y^5 + 23689.3545y^6 - 174858.9840y^7 + 695773.9980y^8 - 1154008.6900y^9.$$

4. A device for viewing under water substantially as hereinbefore described with reference to Figures 1, 2 and 3 or Figs. 1, 2 and 4 of the accompanying drawings.

MARKS & CLERK,
Alpha Tower,
ATV Centre,
Agents for the Applicants.
Birmingham B1 1TT.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1976.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

